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PATENT

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**METHOD FOR EVALUATING AND MEASURING ACCOMMODATION AMPLITUDE AND RANGE AND A DEVICE FOR EMPLOYING SAME**

**BRIEF DESCRIPTION OF THE DRAWINGS**

This application claims priority based on U.S. Provisional Patent Application Serial No. 60/445,554, entitled "Method for Evaluating and Measuring Accommodation Amplitude and Range and a Device for Employing Same," and filed February 6, 2003.

Figure 1 shows a flow diagram illustrating steps of evaluating accommodation amplitude according to versions of the invention.

Figure 2 is an illustration of the effect on the dioptric power of accommodation of the lens of the eye reviewing targets at various distances.

Figure 3 shows evaluation of accommodation amplitude according to prior art methods.

Figure 4 shows the effect of change of distance of a target on retinal image size, i.e. the magnification effect.

Figure 5 shows a restricted range of distance variation that minimizes the magnification effect.

Figure 6 illustrates the effect of a plus or minus lens on the location of the nearest point according to versions of the present invention.

Figure 7 illustrates a side view of one version of an apparatus for evaluating accommodation amplitude according to various versions of the present invention.

Figure 8 illustrates a top view of another version of the apparatus of Figure 7.

Figure 9 illustrates a perspective view of the apparatus shown in Figure 8 further comprising a bridging piece.

Figure 10 is a perspective view of another version of an apparatus for evaluating accommodation amplitude according to the versions of the disclosed method.

Figure 11 is a top view of the back end of the apparatus of Figure 10 showing distance and power markings on the control piece.

Figure 12A illustrates one version of a target displaying relatively large optotypes.

Figure 12B illustrates another version of a target displaying optotypes smaller than on the target of Figure 12A.

Figure 12C illustrates another version of a target displaying optotypes smaller than on the target of Figure 12B.

Figure 12D illustrates another version of a target displaying a design as the optotypes.

Figure 12E illustrates a version of a target comprising a one-way mirror for use in versions of the present invention employing an objective accommodation measuring device.

Figure 12F illustrates a version of an alternative target for use in versions of the present invention employing an objective accommodation measuring device.

Figure 13 illustrates a perspective view of the apparatus of Figure 10 having a target positioned in the holder.

Figure 14 illustrates a perspective view of the apparatus of Figure 13 further having a plus lens within the lens positioner.

Figure 15 illustrates a person having accommodation amplitude for one eye evaluated according to the versions of the present invention.

## **DETAILED DESCRIPTION OF VERSIONS OF THE INVENTION**

Although the disclosure hereof is detailed and exact in order to enable those skilled in the art to practice the invention, the physical versions herein disclosed merely exemplify the invention which may be embodied in other specific structure. The scope of the invention is defined in the claims appended hereto.

Illustrated in the drawings and disclosed herein are versions of a method **10** for evaluating and measuring accommodation amplitude and range in one or both eyes **12** of a person **14**.

Accommodation generally is the adjustment to the lens **16** within the eye **12** to focus on objects located at various near and far distances from the eye **12**. Accommodation is typically measured in diopters (D), an arbitrary measure of the power of refraction. A lens having a dioptric (refractive) power of 1D brings rays of light to a focus point 1 meter from the source of the rays. Similarly, a lens having a power of 2D brings rays of light to a focus point  $\frac{1}{2}$  meter from the source of the rays, and a lens having a power of  $\frac{1}{2}$  D brings rays of light to a focus point 2 meters from the source of the rays. In an eye **12**, the light rays emitted from an image are focused on the retina **18**, which remains a generally fixed and negligible distance from the surface of the lens **16** within the eye **12**.

In order to properly focus images on the retina **18**, the lens **16** of the eye **12** must be adjusted in shape in order to refocus accordingly when the image is near versus when the image is far. Accommodation amplitude (“AA”) is the highest dioptric power of the lens **16** of the eye **12** that is physically achievable. This is generally achieved when a properly focused image is at the nearest point **20** relative to the eye **12** while maintaining proper focus. AA generally varies from person to person.

AA is measured and evaluated according to the versions of the method **10** by determining the nearest point **20** of focus by a person **14** on a target **22** such that the nearest point **20** is located within a predetermined range **24** of distances **26** from the eye **12**, and introducing a sufficiently powered additional lens **28** in front of the eye **12** to ensure that such location is within the predetermined range

24. In one version, a person's eye **12** is evaluated without any distance vision correction in place, i.e. without glasses, contacts, or other corrective lenses via a phoropter or lens trial frame in place to assist the person's general distance vision. In other versions, the person's eye **12** is evaluated using full distance vision correction of some kind in place.

AA is generally calculated by the formula  $(AA) = 100/(distance\ 26\ in\ centimeters\ between\ the\ target\ 22\ and\ the\ eye\ 12\ at\ the\ actual\ nearest\ point\ 20)$ . This may also be referred to as the "gross" AA. According to the versions of the present invention, AA is calculated by the formula  $(AA) = 100/(distance\ 26\ in\ centimeters\ between\ the\ target\ 22\ and\ the\ eye\ 12\ at\ the\ nearest\ point\ 20) - (dioptic\ power\ of\ a\ plus\ or\ minus\ lens\ 30,\ 32\ placed\ in\ front\ of\ the\ eye\ 12\ to\ locate\ the\ nearest\ point\ 20\ within\ the\ predetermined\ range\ 24)$ . This value represents the "net" AA at the nearest point **20** located within the predetermined range **24**. In one version, full distance vision correction is in place during evaluation. In other versions, the right side of the formula for net AA further subtracts the dioptic power of the vision correction that is in place. In yet other versions, net AA is calculated without accounting for the dioptic power of the vision correction.

It is common practice in the industry to measure AA with the person's full distance vision correction in place during examination, but to determine the net AA without subtracting the power of such correction. Similarly, if AA is measured without such correction in place, net AA, according to industry practice,

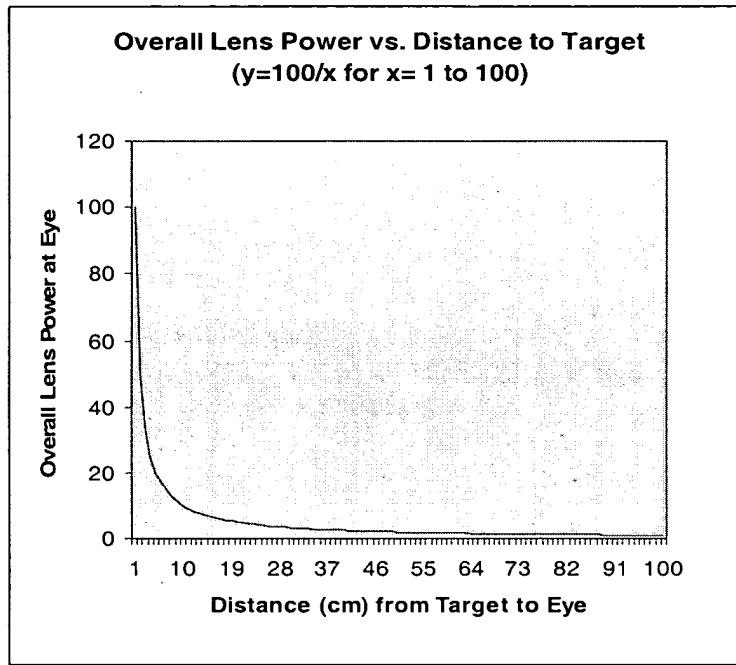
may be determined by subtracting what the correction should have been. For example, if for an eye with -5.0D myopia the person **14** wears the full correction (-5.0D eyeglass lens) and measures a net AA, according to the present invention, of 2.3D, the final value is 2.3D. If, however, the examination is performed without the -5.0D distance correction in place, the value of AA measured according to the present invention will be about 7.3D, but the -5.0D is “added back” to this value to arrive at the net AA of 2.3D, conforming to the common industry practice. As a result, net AA, according to use of the present invention in conformance with common practices, is the gross AA measurement plus the power of an additional lens **28** required to locate the nearest point **20** within the predetermined range **24**. It will be appreciated, however, that net AA may be determined by also subtracting the power of corrective lenses if circumstances dictate or industry practices are adjusted or otherwise changed.

The general formula for measuring net AA above is derived from the rule that lens powers are additive. That is, placing a 1D lens generally adjacent a 3D lens will provide an overall lens power of 4D. According to versions of the invention, at the nearest point **20**, the lens **16** of the eye **12** has its strongest physically achievable dioptric power because the shorter the distance **26** an image has to become focused to a point, the stronger the power of the overall lens required to achieve the focus. If 1D is the focusing power for an image at 1 meter (100 centimeters), then the total power of the overall lens at the eye **12** (i.e. the lens **16** of the eye **12** plus any corrective lens plus any additional lens **28** to locate

the nearest point **20** within the predetermined range **24**) equals 100 divided by the distance **26** in centimeters between the target **22** and the eye **12**. The accommodative power of the lens **16** of the eye **12** is thus the overall lens power at that nearest point **20** minus the powers of any other lenses in the overall lens, such as the additional lens **28**.

AA is evaluated according to versions of the present invention by locating the nearest point **20** within a limited predetermined range **24** of distances **26** from the eye **12** for which a change in distance **26** within the range **24** causes a relatively constant change in the eye's accommodation power. To focus on a target **22** at any distance **26**, the dioptic power of the overall lens (i.e. the accommodated power of the lens **16** of the eye **12** plus the power of any additional lens **28**) equals  $(100)/(distance\ 26\ in\ centimeters\ between\ the\ target\ 22\ and\ the\ eye\ 12)$ . See Graph 1 for the relationship of overall lens power to distance **26** between the target **22** and the eye **12**. This, thus, is an inverse relationship, for which only limited ranges in the most common near-vision distance values (10 centimeters to 60 centimeters) have a relatively constant affect on accommodation.

### Graph 1



In one version, the nearest point **20** (also referred to generally as the “near point”, “blur point” and “point of blur” and referring generally to the point of commencement of blurring of optotypes **34** on a target **22** as the target **22** is brought closer to the eye **12**) is located within a predetermined range **24** of distances **26** from the eye **12** for which the dioptric power of the overall lens is within a range at which a change in distance **26** results in a relatively constant change in dioptric power of the overall lens. In other versions, the predetermined range **24** of potential nearest point **20** locations has a length of between about 10 centimeters and about 50 centimeters. In yet other versions, the predetermined range **24** of potential nearest point **20** locations has a length of between about 15 centimeters and about 25 centimeters. In yet other versions, the predetermined range **24** of potential nearest point **20** locations has a length of about 20

centimeters. In yet other versions, the nearest point **20** is to be located between about 20 centimeters and about 40 centimeters from the eye **12** of the person **14**.

In addition to considering the foregoing factors for identifying a desirable predetermined range **24**, an evaluator **36** using versions of the method **10** may also consider the effect of magnification that occurs when a target's **22** distance **26** from the eye **12** varies greatly. As shown in Figure 4, the image of the target **22** focused on the retina **18** of the eye **12** is magnified when the target **22** is relatively near, and is minimized when the target **22** is moved further away. The magnification effect, according to versions of the invention, is considered in identifying the predetermined range **24**, and dictates a restricted such range, as shown in Figure 5, that avoids artificially aiding a person **14** due to magnified target image that assists focusing on optotypes **34** to resist blurring.

In order to locate the nearest point **20** within the predetermined range **24**, evaluation of AA is first performed without any additional lens **28**. (As discussed above, distance vision correction may be used during this evaluation, and is differentiated from any additional lens **28** used to relocate the nearest point **20** to within the predetermined range **24**.) If the nearest point **20** located in this way is outside the predetermined range **24**, an additional lens **28** is introduced in front of the eye **12** as needed to adjust the location of the nearest point **20**, which adjustment is accomplished by inducing further accommodation of the lens **16** of the eye **12**. If the nearest point **20** is located in front of the predetermined range **24**, a “minus” lens **32** is introduced to push the nearest point **20** away from the

person 14. If the nearest point 20 is located beyond the predetermined range 24, a “plus” lens 30 is introduced to pull the nearest point 20 closer to the person 14. In one version, such plus or minus lenses 30, 32 are introduced by trial and error until the nearest point 20 is located as desired. In other versions, the appropriate plus or minus lens 30, 32 is estimated on the basis of the out-of-range location of the nearest point 20 and the estimated degree of adjustment required to locate the nearest point 20 within the range 24.

As shown in Figure 6, a plus lens 30 generally comprises a convex lens, i.e. a lens thicker in the middle 64 than at the upper and lower ends 66, 68 of the lens in side profile. Such a lens 30 has a “positive” dioptric power. It also has a slight magnification effect that is negligible for purposes hereof for powers up to +3D. Conversely, a minus lens 32 generally comprises a concave lens, i.e. a lens thinner in the middle 64 than at the upper and lower ends 66, 68 of the lens in side profile. Such a lens 32 has a “negative” dioptric power. It also has a slight minification effect that is negligible for purposes hereof for powers down to -3D. Obviously, whether the dioptric power of a lens (either a corrective lens or an additional lens introduced during evaluation) is positive or negative has direct bearing on the dioptric power of the overall lens. Thus, the nearest point 20 may be determined within the predetermined range 24 using such additional lenses 28. In one version, the predetermined range 24 is selected so that plus lenses 30 used in this regard have a power of 3D or less. In other versions, minus lenses 32 used in this regard have a power of -3D or less. The range 24 of locations of nearest

points **20** determined using more than one plus or minus lens **30, 32** may be recorded as needed. AA can be calculated at any position of the target **22** within the predetermined range **24** once the nearest point **20** is known. The accommodative power of the overall lens may be calculated once the distance **26** between the eye and the target **22** at the near point **20** is known.

In one version, the steps for determining the location of the nearest point **20** comprise subjecting the person **14** to a basic near-vision visual acuity test. Such a test may be any recognized or ad hoc test for determining near-vision visual acuity. In other versions, the target **22** in any such test comprises one or more optotypes **34** (testing images) displayed thereon, as shown in Figures 12A-12D. In yet other versions, various targets **22** may be selectively used, each target **22** having optotypes **34** of different sizes than optotypes displayed on other targets. In the latter version, evaluation of AA is performed using at least two different targets **22**, such as in Figures 12B and 12C.

In one version, recognized visual acuity tests are employed. One recognized near-vision visual acuity test comprises a card having the Snellen Test printed thereon (not shown). The Snellen Test is generally known for testing distance vision by placing a Snellen Test chart on a wall and requiring the person to recognize letters on the chart from a distance. In one version of the present invention, the Snellen Test is produced on a card and size-adjusted for near-vision acuity testing and used accordingly for determining the location of the nearest point.

Another recognized near-vision visual acuity test is the Jaeger Test. Referring now to Figures 12A-12C, the Jaeger Test generally comprises a plurality of cards **70** having writing displayed thereon, each card **70** having optotypes **34** of a particular size. For example, card J1 has the smallest optotype size and card J16 has the largest optotype size. In one version of the present invention, one or more cards **70** from the Jaeger Test is used for determining the location of the nearest point **20**. In other versions, the cards J16, J5 and J2 are used for determining the location of the nearest point **20** for each of those cards **70**. Other cards **70** with larger or smaller optotypes **34** may be used according to the visual acuity of the person **14**. In yet other versions, the card J16 is used to familiarize the person **14** in the performance of the AA evaluation method **10** disclosed herein, and cards J5 and J2 are used for taking actual AA measurements in the performance of the AA evaluation method **10** disclosed herein.

In one version, two sizes of optotypes **34** are used and up to two differently powered additional lenses **28** are used to relocate nearest point **20** within the predetermined range **24**. The average reading is then taken after eliminating extreme or skewed readings. The final reading is the determination with the smallest sized optotype **34** such as the card J2 in the Jaeger Test. In other versions, if the person **14** is unable to give reliable readings with the card J2, then the card J5, for example, with larger optotypes **34**, may be used to indicate the final reading. In yet other versions, the optotype size is referenced in the notes, reports or other documentation (not shown) regarding the AA reading, such as in

parentheses, so that the reading of AA may be subjected to correct interpretation by those of ordinary skill in the art and/or those reasonably familiar with the types of cards 70 and optotypes 34 of different visual acuity tests.

In operation, versions of the present invention comprise one or more of the following steps: a person 14 having AA in one or both eyes 12 evaluated is subjected to a near-vision visual acuity test. In one version, the target 22 from such test has generally universally recognizable optotypes 34 of a particular size. The target 22 is positioned in the line of sight of a single eye 12 being tested or parallel to and generally equidistant between the lines of sight of both eyes 12 for a binocular evaluation. The target 22 is gradually moved at an unhurried rate from a distant position to a closer position relative to the eye or eyes 12 until the target 22 reaches the nearest point 20 at which the person 14 initially experiences blurring while viewing the optotypes 34 on the target 22. In one version, the target 22 is moved closer to the eye 12 beyond the nearest point 20 to overshoot it and demonstrate to the person 14 and/or exaggerate the blurring of optotypes 34, then the target 22 is pulled away to make the optotypes 34 clear again, then closer to the point of blur (nearest point) 20. This may be repeated in back and forth movement of the target 22 until reasonable preciseness of the nearest point 20 is determined.

In the event that the nearest point 20 so determined is outside a predetermined range 24 as desired by the evaluator 36, an additional plus lens 30 or minus lens 32 is introduced in front of the eye or eyes 12 as needed, such lens

**28** having a dioptric power sufficient to locate the nearest point **20** to within the predetermined range **24**. The predetermined range **24** is identified in accordance with the above disclosure. A minus lens **32** of sufficient dioptric power is used to push the nearest point **20** away from the eye or eyes **12**, and a plus lens **30** of sufficient dioptric power is used to pull the nearest point **20** closer to the eye or eyes **12**. Once the nearest point **20** is located within the predetermined range **24** of distances **26** from the eye **12** and its relatively precise location is determined for purposes of the evaluation, the net AA is calculated according to the formula  $(AA) = 100/(distance\ 26\ in\ centimeters\ of\ the\ target\ 22\ from\ the\ eye(s)\ 12\ at\ the\ nearest\ point\ 20) - (\text{dioptric\ power\ of\ any\ plus\ or\ minus\ lens}\ 30,\ 32)$ . As discussed above, in one version, full distance vision correction is placed in front of the eye or eyes **12**, such as eyeglasses, contacts, a phoropter, or eyeglasses trial frame (not shown). In other versions, and depending on common industry practices regarding determination of AA, the formula is adjusted accordingly to account for such correction, namely  $(AA) = 100/(distance\ 26\ in\ centimeters\ of\ the\ target\ 22\ from\ the\ eye(s)\ 12\ at\ the\ nearest\ point\ 20) - (\text{dioptric\ power\ of\ any\ plus\ or\ minus\ lens}\ 30,\ 32) + (\text{deficit\ in\ dioptric\ power\ of\ the\ full\ distance\ vision\ correction})$ .

The dioptric power exhibited by a lens **28** introduced in front of the eye(s) **12** in operation is actually slightly lower than the actual dioptric power listed for such lens **28**. This is as a result of the slight distance between the introduced lens and the cornea **72** of the eye **12**. Thus, the more accurate power of any added plus

or minus lens **30, 32** in the overall lens evaluated is the “corneal power” of such lens **30, 32**. The corneal power (“CP”) of any additional lens **28** may be calculated according to the formula  $(CP) = (\text{listed dioptic power of the added plus or minus lens } \mathbf{30, 32}) / (1 - (d * (\text{listed dioptic power of the added plus or minus lens } \mathbf{30, 32})))$ , where  $d$  equals the distance in meters that the added plus or minus lens **30, 32** is located in front of the cornea **72** of the person’s eye **12**. In one version, the value of  $d$  is generally presumed to be about 0.013 meters. However, in light of the relatively small value of  $d$  and its minimal (and arguably negligible) corrective effect on the actual dioptic power of the added plus or minus lens **30, 32**, other versions of the present invention do not use the CP of the introduced lens **28** but rather the actual dioptic power thereof.

In other versions of the present invention, an objective accommodation measuring device (not shown) positioned oppositely facing the eye(s) **12** being evaluated is used to measure AA in conjunction with versions of the disclosed method. In one such version, the objective accommodation measuring device comprises a dynamic retinoscopy machine. In other versions, such a device measures AA in the line of sight of the eye **12** being tested by measuring through the target **22**. In one such version shown in Figure 12E, the target **22** comprises a one-way mirror **74** having a mirror side **76** and a viewer side **78**, the viewer side **78** being opposite the mirror side **76**, the optotypes **34** being displayed on the mirror side **76** in the person’s view. The objective measuring device then measures AA through the viewer side **78** of the one-way mirror **74**. In other such

versions as shown in Figure 12F, the target 22 comprises an aperture 80 extending therethrough, located generally centrally in the target 22. The objective measuring device thus measures AA through the aperture 80.

Table 1 shows results of measured AA in several exemplary test subjects on whom versions of the method 10 of the present invention were performed. The evaluations were conducted under standard conditions. The near-vision visual acuity test comprised the Jaeger Test, using cards J16, J5 and J2. The predetermined range 24 was identified to be 20 centimeters long and having a nearest point 20 distance range of between 20 centimeters and 40 centimeters from each test subject's eye 12 on the basis of the relatively straight line relationship of overall lens power between 20 cm and 40 cm (overall power = 5D at 20 cm and 2.5D at 40 cm). (See Graph 1, supra.)

Table 1

<u>Test Subject</u>	<u>Nearest Point</u>	<u>Overall Lens Power</u>	<u>Correction Power</u>	<u>Additional Lens Power</u>	<u>Measured AA</u>
#1	31.25 cm	3.2	0	1.0	2.2
#2	23.26 cm	4.3	0	2.0	2.3
#3	32.26cm	3.1	0	2.0	1.1
#4	23.81cm	4.2	0	3.0	1.2

Various apparatuses **38** may be employed for performing the various versions of the method **10** disclosed herein and for measuring AA. Such apparatuses **38** generally have means for presenting a target **22** to the person **14** at varying distances **26**. In one version, such means comprise a track-and-slide arrangement **82** for moving a target **22** nearer and farther from the eye **12**. In other versions, such means comprise an optical system (not shown) displaying a virtual image of the target. Such an optical system may comprise an arrangement of mirrors or a screen display of computer or micro-processor generated images.

Versions of an apparatus **38** comprising a track-and-slide arrangement **82** are shown in Figures 8-11 and 13-15. In one version, the apparatus **38** comprises a holder **40**, a slide rule or vernier **42**, and a lens positioner **44**. The slide rule or vernier **42** comprises a track **46** and a control piece **48**. In one such version, the control piece **48** slideably engages the track **46** coaxially so that the control piece **48** is slideably movable the length of the track **46**. In another such version, the control piece **48** threadedly engages the track **46** coaxially so that the control piece **48** is threadedly movable the length of the track **46**. The holder **40** is connected to one end **84** of the control piece **48** and is movable relative to the track **46** by pushing or pulling the control piece **48** having a slideable engagement, or, for threaded engagements, turning the control piece **48** clockwise or counterclockwise relative the track **46** to screw or unscrew the threaded engagement. The holder **40** is configured to receive the target **22** used for the evaluation. The lens positioner **44** is provided at the end **62** of the apparatus **38**.

which is mounted adjacent the eye **12** being evaluated. The lens positioner **44** is configured to receive a lens **28** introduced for adjusting the location of the nearest point **20** to within the predetermined range **24** of distances **26** from the eye **12**, as shown in Figure 14.

In one version, the apparatus **38** is mounted adjacent the eye **12** of the person **14**, for example at the inferior orbital margin **50** of the eye **12**. So mounted, the track **46** and control piece **48** are substantially aligned with the line of sight for the eye **12**. In other versions, the apparatus **38** further comprises a bridge piece **52** removably secured to the end **62** of the apparatus for mounting the apparatus **38** adjacent the bridge **54** of the person's nose between the person's eyes **12**. In such versions, the apparatus **38** is employed for binocular evaluation of AA, and the track **46** and control piece **48** are aligned substantially parallel to and equidistant between the lines of sight for each of the person's eyes **12**. A control piece **48** will be moved gradually toward the eye **12**. In one version, this movement is relatively slow, at an unhurried rate, generally less than about 2 cm per second.

In versions shown in Figures 8-14, the apparatus **88** further comprises a plurality of distance markings **56** displayed along the track **46** or on the control piece **48**. The markings **56** indicate relative distances **26** of target **22** from a person's eye **12** when the apparatus **38** is appropriately mounted adjacent the eye **12**. In one version shown in Figure 8, the apparatus **38** further comprises a reference point marker **58** that is movably mounted adjacent the track **46**. In such

versions, the marker **58** has a length generally consistent with the length of the predetermined range **24** for locating the nearest point **20**. In one such version, the marker **58** is mounted adjacent the track **46** to indicate distances **26** within which to locate the nearest point **20** as between about 10 centimeters and about 60 centimeters from the eye **12**. In other such versions, the length of the marker **58** is from about 10 centimeters long to about 50 centimeters long. In yet other such versions, the marker **58** is from about 15 centimeters long to about 25 centimeters long. In yet other such versions, the marker **58** is about 20 centimeters long. In yet other such versions, the marker **58** is mounted adjacent the track **46** in order to locate the nearest point **20** between about 20 centimeters from the eye **12** and about 40 centimeters from the eye **12**. By fixing the target **22** in position or minimizing the movement of the target **22** from about 15 centimeters to about 40 centimeters and using lenses **28** in front of the eye **12** to find the point of blur which corresponds to the nearest point **20**, the effect of magnification and minification of the retinal image during evaluation is mitigated.

In versions shown in Figures 10 and 11, a reference mark **60** is provided along the track **46** and markings **56** are provided on the control piece **48** that indicate the distance **26** between a person's eye **12** and the holder **40**. The markings **56** are calibrated to display this distance **26** at the reference mark **60**. As shown in Figure 11, the dioptic power of the gross AA, calculated according to the formula  $(AA)=100/distance\ (cm)$ , is also displayed in the markings **56** relative to a particular distance **26**. In versions of the method **10** disclosed above,

the calculating step is deemed to be performed also by taking readings from an apparatus **38** that indicates the gross AA at various nearest points **20** and subtracting the power of a plus or minus lens **30, 32**, if any.

In one version of the apparatus **38**, movement of the control piece **48** may be provided mechanically and/or manually. In other versions, the distance **28** may be determined electronically within the apparatus **38** and displayed on an LCD or other appropriate digital display screen (not shown) mounted on the apparatus **38**. In yet other versions, the gross AA is electronically determined and displayed on such a screen (not shown).

The apparatuses **38** shown in Figures 7-9 may have a mounting end **62** configured for mounting directly adjacent the eye **12**, such as by placing the end **62** against the inferior orbital margin **50** of the eye **12**. In other versions, the mounting end **62** is configured for mounting the apparatus **38** on a phoropter (not shown) used in connection with the versions of the method **10** disclosed herein.

In other versions, AA as well as the range of accommodation may be evaluated and measured. In such versions, rather than moving the target **22** in order to find a nearest point **20** located within the predetermined range **24**, the target **22** is fixed in a position within the predetermined range **24**, and a series of plus and/or minus lenses **30, 32** are introduced in front of the eye **12** to determine the range of powers of such added plus and/or minus lenses **30, 32** for which the person **14** can recognize the optotypes **34** displayed on the target **22**. As a result of determining such a range, one may also determine the range of accommodation

of the lens **16** of the eye **12** that is physically achievable because the lens **16** of the eye **12** will have adjusted from its highest power to its weakest power. In determining accommodation range, in one version the concern is with the range of the lens **16** of the eye **12** alone. For such evaluations, the power of the distance vision correction in place is subtracted from the gross accommodation.

For example, if the target **22** is fixed a distance **26** of 20 centimeters from the eye **12**, the power of the overall lens (the gross accommodation), as described above, is 5D. Assuming no distance vision correction is needed for the person **14**, the accommodation power of the lens **16** of the eye **12** is 5D. By introducing lenses **28** in front of the eye **12** having powers between -5D and 15D and subjecting the person **14** to the near-vision visual acuity test, visual acuity is evaluated for powers of the overall lens between 0D (no refraction at all) and 20D. Without refraction by the overall lens, the person **14** will not be able to recognize the optotypes **34**. The power of the lens **28** introduced in front of the eye **12** for which the person **14** can first recognize optotypes **34** on the target **22** is generally the equivalent of the lens used to adjust the nearest point **20** to within the predetermined range **24**, as described above. Thus, AA is measured for an “equivalent” nearest point **20** of 20 centimeters by subtracting the power of the introduced lens **28** from 5D.

By continuing the progression through the series of lenses **28** up to 15D, at some point the person **14** will no longer be able to recognize the optotypes **34** on the target **22**. The stronger the dioptic introduced lens **28**, the weaker the dioptic

power of the lens **16** of the eye **12**. When the person **14** can no longer recognize the optotypes **34** at 20 centimeters, the weakest power that the lens **16** of the eye **12** can physically achieve has been reached, and may be calculated using the same formula provided for calculating AA, wherein AA instead equals the weakest physically achievable power of the lens **16** of the eye **12**. Thus, the range of accommodation of the lens **16** of the eye **12** is determined.

An apparatus **38**, including any apparatus disclosed herein, that is suitable for the moving target method disclosed above may also be employed for evaluating AA and range of accommodation pursuant to the stationary target method described above.

While specific versions of the invention have been shown and described herein for purposes of illustration, the protection offered by any patent which may issue upon this application is not strictly limited to the disclosed versions; but rather extends to all structures, steps and arrangements which fall fairly within the scope of the claims which are appended hereto: